Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division

Digital Learning Handout

Part A: Content Design

Course Title	Artificial and Computational Intelligence
Course No(s)	AIML ZG557
Credit Units	5
Credit Model	1.25 - 1.5 - 2.25
Course Author	Profs. Vimal SP, Raja Vadhana Prabhakar
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Version No:	6.0
Date:	30/03/2026

Course Description:

Agents and environments, Task Environments, Working of agents; Uninformed Search Algorithms: Informed Search. Local Search Algorithms & Optimization Problems: Genetic Algorithm; Searching with Non-Deterministic Actions, Partial Information and Online search agents, Game Playing, Constraint Satisfaction Problem, Knowledge Representation using Logics: TT-Entail for inference from truth table, Proof by resolution, Forward Chaining and Backward Chaining, Inference in FOL, Unification & Lifting, Forward chaining, Backward Chaining, Resolution; Probabilistic Representation and Reasoning : Inference using full joint distribution, Representation of Conditional Independence using BN, Reinforcement Learning; Difference between crisp and fuzzy logic, shapes of membership function, Fuzzification and defuzzification, fuzzy logic reasoning; Decision making with fuzzy information, Fuzzy Classification; Connectionist Models: Introduction to Neural Networks, Hopfield Networks, Perceptron Learning, Back propagation & Competitive Learning, Applications of Neural Net: Speech, Vision, Traveling Salesman; Genetic Algorithms - Chromosomes, fitness functions, and selection mechanisms, Genetic algorithms: crossover and mutation, Genetic programming.

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Course Objectives

No	Course Objective
CO1	Identify and recall fundamental concepts and techniques for designing intelligent agents
CO2	Represent and use of knowledge in inference-based problem solving approaches
CO3	Apply probability theory to describe and model agents operating in uncertain environments
CO4	Implement optimisation models of computation and processing in real world application of intelligent agents
CO5	Apply principles of cooperative and competitive multi-agent decision making by constructing conceptual frameworks

Text Book(s):

T1	Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Pearson Education, 2020. Fourth Edition

Reference Book(s) & other resources:

R1	Ryszard S. Michalski, Jaime G. Carbonell and Tom M. Mitchell, "Machine Learning: An Artificial Intelligence Approach", Elsevier, 2014
R2	Dan W Patterson, "Introduction to AI and Expert Systems", Prentice Hall of India, New Delhi, 2010
R3	Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill Publishing Company, New Delhi, 2003. Second Edition

Learning Outcomes: Students will be able to

LO1	Understand and recall agent-environment interactions through architectures and design PEAS descriptions of agents. Measure success by the agent's ability to perform tasks such as pathfinding and decision-making.
LO2	Design and implement heuristic functions in search algorithms like A* and measure its efficiency through the number of nodes expanded and the solution's optimality.
LO3	Design and implement the local search algorithms like Hill Climbing, simulated annealing and evolutionary techniques like Genetic algorithm, Ant Colony Optimization, particle swarm optimization for designing solutions for N-Queen problem or Travelling Salesman problem.

LO4	Design static evaluation measure for building adversarial search agents in multiplayer player Games and implement Game playing using algorithms like Minimax, Alpha Beta pruning, and Monte Carlo Tree Search.
LO5	Apply logical inference techniques to solve problems like agent navigation in a Grid World. Measure success by the correctness and efficiency of inferred solutions.
LO6	Apply cooperative and competitive multi-agent decision-making principles by constructing conceptual frameworks that demonstrate coordination, negotiation, and conflict resolution in multi-agent environments.
LO7	Apply probabilistic models for decision-making under uncertainty using Bayesian networks with exact inferencing, approximate inferencing by direct sampling. Implement solutions for temporal problems and learn the parameters of Hidden Markov Models.
LO8	Understand the importance of ethical considerations while designing AI solutions.

Modular Content Structure

1. Introduction
    - Artificial Intelligence: Foundations, Overview of Modern AI & Application Domains.
2. Introduction to Intelligent Agents: Notion of Agents and Environments, Rationality, Nature of Environments, Structure of Agents
3. Problem Solving Agent using Search:
    - Problem Formulation, From Uninformed to Informed Search Algorithms– Informed Search Algorithms: Notion of Heuristics, Greedy best first search, A* search, Optimality of A*
    - Heuristic Functions: Heuristic Accuracy & Algorithm performance, Admissible heuristics from relaxed problems, pattern databases & Experience, Learning Heuristics
    - Local Search Algorithms & Optimization Problems: Hill Climbing Search, Local Beam Search, Evolutionary Algorithm - Genetic Algorithm, Bioinspired Algorithm - Ant Colony Optimization
    - Neural Architecture Search: Introduction, Neuro Evolution
4. Game Playing:

- Searching to play games: Minimax Algorithm, Alpha-Beta Pruning
- Monte Carlo Tree Search
- Stochastic Games

5. Knowledge Representation using Logics:
   - Overview of Logics- Propositional, Predicate, TT-Entail, Theorem Proving
   - Logic Representation of a sample agent, Proof by resolution, DPLL Algorithm, Agents based on Propositional logic
   - Unification, forward chaining, Backward Chaining, Resolution
6. Multi agent Decision Making:
   - Multi agent Planning: Properties of Multi agent environments
   - Non-Cooperative Game Theory
   - Cooperative Game Theory
   - Making Collective Decisions
7. Probabilistic Representation and Reasoning
   - Representing Knowledge in an Uncertain Domain
   - The Semantics of Bayesian Networks
   - Exact Inference in Bayesian Network
   - Approximate Inference in Bayesian Networks
8. Probabilistic Reasoning over time
   - Time and Uncertainty
   - Overview of inference in Temporal Models - Hidden Markov Models - Learning HMM
   - Dynamic Bayesian Networks
9. Ethics in AI
   - Explainable AI- Logically Explained Network, Explainable Bayesian Network

Part B: Learning Plan

Contact Session	List of Topic Title	Sub-Topics	Reference
1-a)	**Introduction**	● What is Artificial Intelligence: Acting Humanly, Thinking	T1: 1.1

		humanly, Thinking rationally, Acting Rationally ● Foundations of AI , Brief Overview of Modern AI & Application Domains.	T1: 1.2, 1.4, 1.5
1-b)	**Introduction to Intelligent Agents**	● Intelligent Agents: Notion of Agents and Environments, Rationality ● Nature of Environments, Structure of Agents	T1: Chapter 2
2	**Problem Solving Agent using Search**	● Problem Solving Agent ● Problem Formulation - Examples ● From Uninformed to Informed Search Algorithms ● Notion of Heuristics ● Informed Search Algorithms : Greedy best first search, A* search ● Optimality of A*	T1: Chapter 3.1-3.3, 3.5.1 - 3.5.4
3	**Problem Solving Agent using Search**	● Heuristic Functions ● Heuristic Accuracy & Algorithm performance ● Admissible heuristics from relaxed problems, pattern databases. & Experience ● Use case : Learning Heuristics using Supervised Learning	T1: Chapter 3.6 Research Paper : NeurIPS 2023
4	**Problem Solving Agent using Search**	● Local Search Algorithms & Optimisation Problems ● Hill Climbing Search ● Local Beam Search ● Online Search Agents	T1: Chapter 4.1, 4.5
5	**Problem Solving Agent using Search**	● Genetic Algorithm ● Ant Colony Optimisation	T1: Chapter 4.1, Research papers & web resources
6	**Problem**	● Neural Architecture	Research papers

	Solving Agent using Search	Search ● Use case : Neuro Evolution - Evolutionary computation to design or train neural networks	& web resources Research Paper: NAS Research paper : CoDeepNEAT
7	**Game Playing**	● Searching to play games ● Minimax Algorithm ● Alpha-Beta Pruning	T1: Chapter 6.1, 6.2, 6.3
8	**Game Playing**	● Monte Carlo Tree Search ● Stochastic Games	T1: Chapter 6.4, 6.5
9	**Knowledge Representation using Logics**	● Logical Agent, Logic Representation of a sample agent ● DPLL Algorithm, Agents based on Propositional logic ● First Order Logic	T1: Chapter 7.1, 7.2, 7.5.2, 7.5.3, 7.6.1, 8.3.4
10	**Knowledge Representation using Logics**	● Inference in First Order Logic, Unification ● Forward chaining, Backward Chaining ● Resolution	T1: Chapter 9
11	**Multi agent Decision Making**	● Properties of Multi agent environments ● Non-Cooperative Game Theory	T1: Chapter 17
12	**Multi agent Decision Making**	● Cooperative Game Theory ● Making Collective Decisions	T1: Chapter 17
13	**Probabilistic Representatio**	● Representing Knowledge in an Uncertain Domain	T1: Chapter 13

	n and Reasoning	● The Semantics of Bayesian Networks ● Exact Inference in Bayesian Network ● Approximate Inference in Bayesian Networks	
14	**Probabilistic Reasoning over time**	● Time and Uncertainty ● Overview of Inference in temporal models - Hidden Markov Models	T1: Chapter 14.1, 14.2, 14.3
15	**Probabilistic Reasoning over time**	● Learning HMM ● Dynamic Bayesian Networks	T1: Chapter 21.3.3-20.3.4, 14.5
16	**Ethics in AI**	● Explainable AI- Logically Explained Network, Explainable Bayesian Network	Research papers & web resources

Experiential Learning Components:

1. Lab work: 7
2. Project work: 0
3. Case Study: 0
4. Simulation: 0
5. Work Integrated Learning Assignment- 2 Assignments
6. Design work/ Field work: 0

Objective of Experiential Learning Component:
Learners will implement informed/uninformed/local search algorithms, adversarial search and Bayesian networks using Python, rule-based systems in Prolog

Scope of Experiential Learning Component:
Programming language – Python, Prolog
Tools and libraries: Jupyter, Numpy, Scipy, Pandas, pgmpy, nltk

Lab Infrastructure:
Google Colab, Online: https://www.swi-prolog.org/

List of Experiments:

Lab No	Lab Objective	Session Reference
1	Implement Uninformed Search Algorithms like BFS/DFS	2
2	Implement A* algorithm for Informed Search	3
3	Implement Local Search Techniques using Genetic Algorithm	5
4	Implement MINIMAX algorithm for Adversarial Search in game playing	7, 8
5	Represent knowledge using logics and perform reasoning using PROLOG	10
6	Experiment with Bayesian Networks and exact Inferencing	13
7	Experiment with application of Hidden Markov Model in Natural Language Processing	15

Evaluation Scheme:

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

Evaluation Component	Name (Quiz, Lab, Project, Mid-term exam, End semester exam, etc.)	Type (Open book, Closed book, Online, etc.)	Weight	Duration	Day, Date, Session, Time
EC – 1*	Quiz I	Online	5%	1 day	August 10-20, 2026
	Lab Assignment	Online	13%	10 days	To be announced
	Lab Assignment	Online	12 %	10 days	To be announced
EC - 2	Mid-Semester Test	Closed	30%	2 hours	19/09/2026

		Book			(FN)
EC - 3	Comprehensive Exam	Open Book	40%	2 ½ Hours	05/12/2026 (FN)

EC1* (30%): Quiz: 5 %, Lab Assignment/Assignment: 25%
Syllabus for Mid-Semester Test (Closed Book): Topics in Contact session: 1 to 8
Syllabus for Comprehensive Exam (Open Book): All topics

Important Links and Information:
eLearn Portal: https://elearn.bits-pilani.ac.in
Students must visit the eLearn portal regularly and stay updated with the latest announcements and deadlines.
Contact Sessions: Students should attend the online lectures as per the schedule provided on the eLearn portal.
Evaluation Guidelines:

1. EC-1 consists of either two Assignments or three Quizzes. Students will attempt them through the course pages on the eLearn portal. Announcements will be made on the portal in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: "open book" means text/ reference books (publisher copy only) and does not include any other learning material. No other learning material will be permitted during the open book examinations. For Detailed Guidelines refer to the attached document.
   EC3 Guidelines
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam, which will be made available on the eLearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignments/Quizzes, Mid-Semester Tests and Comprehensive Exams according to the evaluation scheme provided in the handout.

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